

CLAIMS

1. A method for automatic dose control of a liquid treatment chemical during a liquid treatment process within a treatment system, the system having an influent flow and an effluent flow, the method comprising:

a. measuring the liquid flow rate through the treatment system and generating a liquid flow rate signal from the measurement;

b. measuring the concentration of a chemical within the treatment system and generating a chemical concentration signal from the measurement;

c. transmitting the signal generated from step (a) and the signal generated from step (b) to a chemical dosing controller;

d. automatically calculating the dosage of a chemical from signals supplied to the chemical dosing controller;

e. transmitting an output signal from the chemical dosing controller to a chemical feeding system, the output signal based on dosage calculated in step (d);

f. releasing the chemical from step d into influent flow in response to output signal of step (e); and

g. repeating steps (a)-(f) continuously during the liquid treatment process.

2. The method of claim 1 wherein the of liquid flow rate is measured in the influent flow of the system.

3. The method of claim 1 wherein the liquid flow rate is measured in the effluent flow of the system.

4. The method of claim 1 wherein the liquid flow rate is adjusted by a multiplier.

5. The method of claim 1 wherein the concentration of the chemical in step (b) is measured in the influent flow of the system.

1 6. The method of claim 1 wherein the concentration of the chemical in
2 step (b) is measured in the effluent flow of the system.

1 7. The method of claim 1 wherein the concentration of the chemical in
2 step (b) is measured both in the effluent flow and in the influent flow of the
3 system.

1 3/8. The method of claim 1 wherein the chemical in step (b) is the same
2 chemical as in step (d).

1 4/8. The method of claim 1 wherein the chemical in step (b) is a different
2 chemical from the chemical in step (d).

1 5/10. The method of claim 1 wherein the measurement of the liquid flow
2 rate in step (a) and the concentration of the chemical in step (b) is
3 performed continuously.

1 6/11. The method of claim 1 wherein the measurement of the liquid flow
2 rate in step (a) is continuous and the measurement of the concentration of
3 the chemical in step (b) is performed at intervals within a range of from a
4 fraction of a second to approximately 15 minute intervals.

1 7/12. The method of claim 1 wherein the liquid of the liquid treatment
2 process is water and the treatment process is a water treatment process.

Sub #3 13. A method for automatic dose control of nitrate-nitrogen during a
2 water treatment process within a denitrification treatment system using a
3 chemical source of organic carbon as the feed chemical, the system having
4 an influent flow and an effluent flow, the method comprising:

- 5 a. measuring the water flow rate through the treatment system and
6 generating a water flow rate signal from the measurement;
7 b. measuring the concentration of nitrate-nitrogen within the influent
8 flow of the treatment system and generating a chemical concentration
9 signal from the measurement;

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- 10 c. transmitting the signal generated from step (a) and the signal
11 generated from step (b) to a chemical dosing controller;
12 d. automatically adjusting the nitrate/nitrogen signal by at least one
13 adjustable dose factor;
14 e. automatically calculating the dosage of the feed chemical from
15 adjusted signals supplied to chemical dosing controller;
16 f. transmitting an output signal from the chemical dosing controller to a
17 chemical feeding system, the output signal based on dosage calculated in
18 step (e);
19 g. releasing the feed chemical into the influent flow in response to the
20 output signal of step (f); and
21 h. repeating steps (a)-(g) continuously during the denitrification
22 process.

1 14. The method of claim 13 wherein the feed chemical is selected from
2 the group consisting of alcohol and volatile fatty acid.

1 15. The method of claim 14 wherein the feed chemical is methanol.

Sub A4 1 16. The method of claim 13 wherein the water flow rate signal of step (c)
2 is automatically adjusted by a flow pace multiplier.

1 17. The method of claim 13 wherein the concentration of the nitrate-
2 nitrogen is measured both at the effluent flow and at the influent flow of the
3 system.

Sub A5 1 18. The method of claim 17 wherein a setpoint for effluent nitrate-
2 nitrogen is selected, an effluent flow concentration signal is generated from
3 the measurement of concentration of nitrate-nitrogen in the effluent flow
4 and the concentration signal is transmitted to the chemical dosing
5 controller.

1 ¹³~~19~~. The method of claim ¹²~~18~~ wherein the difference between the effluent
2 concentration of nitrate-nitrogen and the setpoint is calculated to generate
3 a control response, the control response is adjusted by one or more
4 sensitivity factors and the adjusted control response is automatically
5 incorporated into the calculation for the dosage of the feed chemical.

Sub A6 1 20. The method of claim 19 wherein the dosage is used to generate a
2 modified output signal which is transmitted from the chemical dosing
3 controller to the chemical feeding system.

1 ¹⁵~~21~~. The method of claim ¹⁴~~20~~ wherein the modified output signal from the
2 chemical dosing controller to the chemical feeding system is transmitted
3 after a reset time.

1 ¹⁶~~22~~. The method of claim ¹⁵~~21~~ wherein the reset time is input manually.

1 ¹⁷~~23~~. The method of claim ¹⁵~~21~~ wherein the reset time is an automatically
2 calculated variable based on the hydraulic residence time through the
3 process and the process reaction time.

Sub A7 1 24. The method of claim ¹⁸~~13~~ wherein the nitrate-nitrogen signal is
2 automatically adjusted by at least one adjustable dose factor.

1 25. A method for automatic dose control of nitrate-nitrogen during a
2 water treatment process within a denitrification treatment system using a
3 chemical source of organic carbon as the feed chemical, the system having
4 an influent flow and an effluent flow, the method comprising:

- 5 a. selecting a setpoint for effluent nitrate-nitrogen;
6 b. measuring the water flow rate through the treatment system and
7 generating a water flow rate signal from the measurement;
8 c. measuring the concentration of nitrate-nitrogen in the effluent flow
9 and generating a chemical concentration signal from the measurement;

- 10 d. transmitting the signal generated from step (b) and the signal
11 generated from step (c) to a chemical dosing controller;
12 e. calculating the difference between the effluent concentration of
13 nitrate-nitrogen and the setpoint to generate a control response;
14 f. adjusting the control response by one or more sensitivity factors;
15 g. automatically calculating the dosage of the feed chemical from the
16 control response;
17 h. transmitting output signal from chemical dosing controller to the
18 chemical feeding system, the output signal based on dosage calculated in
19 step (g);
20 i. releasing the feed chemical into influent flow in response to output
21 signal of step (h); and
22 j. repeating steps (a)-(i) continuously during the denitrification process.

1 ²⁰26. The method of claim 25 wherein the concentration of nitrate-nitrogen
2 is measured in both the influent flow and the effluent flow.

1 ²¹27. The method of claim 26 wherein the concentration of the of nitrate-
2 nitrogen in the influent flow is measured and an influent flow concentration
3 signal is generated and transmitted to the chemical dosing controller.

Sub A8 1 28. The method of claim 27 wherein the influent flow concentration signal
2 is adjusted by an adjustable dose factor and the water flow rate signal from
3 step (d) is adjusted by a flow pace multiplier.

1 29. The method of claim 27 wherein the calculation of an output signal
2 from the chemical dosing controller to the chemical feeding system is
3 based on water flow rate, concentration of nitrate-nitrogen in the influent
4 flow and concentration of nitrate-nitrogen in the effluent flow.

1 30. The method of claim 25 wherein the calculation of succeeding
2 control responses in step (e) is performed after a reset time.

- 1 ²⁵31. The method of claim ²⁴30 wherein the reset time is input manually.
- 1 ²⁴32. The method of claim ²⁴30 wherein the reset time is an automatically
2 calculated variable based on the hydraulic residence time through the
3 process and the process reaction time.
- 1 ²⁴33. The method of claim ²⁴30 wherein a derivative control response is
2 generated to counteract rapid rates of change towards or away from the
3 setpoint.
- 1 ²⁴34. The method of claim ²⁷33 wherein a derivative control response is
2 generated by determining a first effluent concentration prior to the reset
3 time, a second effluent concentration is measured at the reset time,
4 comparing the first effluent concentration to the second effluent
5 concentration and adjusting the control response accordingly.
- 1 ²⁹35. A method for automatic dose control of a liquid treatment chemical
2 during a treatment process within a liquid treatment system using a feed
3 chemical, the system having an influent flow and an effluent flow, the
4 method comprising:
5 a. selecting a setpoint for a chemical in the effluent flow;
6 b. measuring the liquid flow rate through the treatment system and
7 generating a liquid flow rate signal from the measurement;
8 c. measuring the concentration of the chemical of step (a) in the influent
9 flow and generating an influent chemical concentration signal from the
10 measurement;
11 d. measuring the concentration of the chemical of step (a) in the
12 effluent flow and generating an effluent chemical concentration signal from
13 the measurement;
14 e. transmitting the signal generated from step (b) to a chemical dosing
15 controller and generating a primary control response;
16 f. adjusting the primary control response by a flow pace modifier;

- 17 g. transmitting the signal generated from step (c) to a chemical dosing
18 controller and generating a secondary control response;
19 h. adjusting the secondary control response by an adjustable dose
20 factor;
21 i. transmitting the signal from step (d) to the chemical dosing controller
22 and calculating the difference between the effluent chemical concentration
23 and the setpoint to generate a tertiary control response;
24 j. adjusting the tertiary control response by one or more sensitivity
25 factors;
26 k. continuously calculating the dosage of the feed chemical from the
27 primary control response and secondary control response while
28 incorporating the tertiary control response from step (f) after a reset period;
29 l. transmitting an output signal from chemical dosing controller to a
30 chemical feeding system, the output signal based on dosage calculated in
31 step (k);
32 m. releasing a feed chemical into influent flow in response to output
33 signal of step (l); and
34 n. repeating steps (a)-(m) continuously during the treatment process.
- 1 ³⁰ 36. The method of claim ²⁹ 35 wherein the chemical in step (a) is the same
2 chemical as in step (m). ²⁹
- 1 ³¹ 37. The method of claim ²⁹ 35 wherein the chemical in step (a) is a different
2 chemical from the chemical in step (m). ²⁹
- 1 ³² 38. The method of claim ²⁹ 35 wherein the reset time is input manually. ²⁹
- 1 ³³ 39. The method of claim ²⁹ 35 wherein the reset time is an automatically
2 calculated variable based on the hydraulic residence time through the
3 process and the process reaction time.